

Assessment of the Rice Lake Muskellunge Population, 2014-2015  
Barron County, WI  
MWBIC Code: (2103900)



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## Executive Summary

Muskellunge (*Esox masquinongy*) were sampled in Rice Lake during 2014 and 2015 using mark and recapture methodology to estimate abundance and size structure of adult ( $\geq 30$  in) fish. Fish were collected in spring with fyke nets set shortly after ice out, marked, and sampled one year post marking. Abundance of adult muskellunge was estimated using Chapman's modification of the Petersen single-census method. There were 68 adult ( $\geq 30$  in) muskellunge (41 males and 27 females) marked in 2014 and 62 adult muskellunge (27 males and 35 females) collected in 2015. Of the muskellunge captured in 2015, there were 15 (7 males and 8 females) recaptures marked in 2014. The adult population (sexes combined  $\geq 30$  in) was estimated to be 271 fish (95% CI: 160-382), or 0.29 adult fish/acre. The population increased from the 2007 survey, when abundance was estimated to be 147 fish (95% CI: 98-196) or 0.16 adult fish/acre. The abundance estimates by length group for 2014 were: 59 from 30.0-33.9 in; 98 from 34.0-37.9 in; 90  $\geq 38$  in; and 69  $\geq 40$  in. Abundance of muskellunge  $\geq 38$  in and  $\geq 40$  in length groups were similar to those of the 2007 survey. However, the abundance of the smaller length groups (i.e., 30.0-33.9 and 34.0-37.9 in) appeared to have increased when compared to the 2007 survey. Adult muskellunge collected in this survey were in fair condition and had above average growth rates. Rice Lake should be managed for a moderate density (0.3-0.4 fish/acre) population with high size structure. The muskellunge stocking rate should be maintained at 1.5 large fingerlings/acre on an alternate year basis, which should continue to provide increased recruitment and bring the population within the target population density range. For assessing population parameters (i.e., growth and mortality rates), all muskellunge handled in future Rice Lake muskellunge surveys should be implanted with Passive Integrated Transponder (PIT) tags. Rice Lake is on a six-year rotation for comprehensive surveys. The next muskellunge population estimate will be in 2020. Special attention should be given to changes in growth rates, condition, and size structure of muskellunge. In addition, the effectiveness of the 50 in minimum length limit should be evaluated.

## Introduction

Rice Lake is a 939-acre drainage lake in northeast Barron County Wisconsin and is located within the limits of the City of Rice Lake. The lake has a maximum depth of 19 feet, and a mean depth of 9 feet (Figure 1). Rice Lake has 18.5 miles of shoreline, with much of it developed. The Red Cedar River enters on the east side of Rice Lake and flows out the dam on the west side of the lake. The dam has 12 feet of head and is operated by Barron County. Stump Lake is a 129 acre drainage lake that is connected to the northern portion of Rice Lake. Bear Creek flows through Stump Lake and ultimately into Rice Lake. Stump Lake is shallow with a maximum depth of 9 ft. and mean depth of 5 ft.

Rice Lake has a diverse fish community that is comprised of muskellunge (*Esox masquinongy*), northern pike (*E. Lucius*), largemouth bass (*Micropterus salmoides*), smallmouth bass (*M. dolomieu*), bluegill (*Lepomis macrochirus*), pumpkinseed (*L. gibbosus*), black crappie (*Pomoxis nigromaculatus*), yellow perch (*Perca flavescens*), rock bass (*Ambloplites rupestris*), bullheads (*Ameiurus spp.*), white sucker (*Catostomus commersoni*), redhorse (*Moxostoma spp.*), bowfin (*Amia calva*), common carp (*Cyprinus carpio*), golden shiner (*Notemigonus crysoleucas*), and walleye (*Sander vitreus*) are present in low numbers.

Anglers have access to the lake by five public boat landings and two public fishing piers. The only special fishing regulation is for muskellunge, which have a 50-inch minimum length limit (MLL) and one fish daily bag limit. The 50-inch MLL was implemented in 2012, with the overall goal of maximizing the trophy potential of the lake (Benike 2008). Prior to this regulation, Rice Lake muskellunge were managed with a 40-inch MLL with a one fish daily bag since 1998. All other species regulations follow the Wisconsin statewide fishing regulations.

Rice Lake supports a respectable muskellunge fishery that is popular among anglers. Although muskellunge are not native to Rice Lake (Becker 1983), the lake has been managed for muskellunge since 1987, when the Wisconsin Department of Natural Resources (WDNR) initially stocked muskellunge. Muskellunge are not known to naturally reproduce in Rice Lake; therefore, the reproductive classification is considered to be Category 3, where stocking is necessary to maintain the population (WDNR 2012).

Rice Lake is currently considered and managed as an A1 muskellunge water, defined by its ability to produce large fish, but the overall abundance of muskellunge is lower compared to other muskellunge waters (WDNR 2012).

Muskellunge have been stocked in Rice Lake at varying rates through the years. From 1987-1991, muskellunge were stocked annually at a rate of approximately 1.5 fish/acre. From 1993-1999, muskellunge were stocked in odd numbered years at the same rate, except in 1997 when no muskellunge were stocked. In 2001, stocking was reduced to approximately 1.0 fish/acre during odd numbered years. The muskellunge stocking rate was again changed in 2011 and was increased to 1.5 fish/acre on an alternate year basis following a recommendation from Benike (2008; Table 1).

The most recent muskellunge survey was conducted in 2007-2008, and survey data indicated the adult muskellunge population to be at a low density with good size structure and condition (Benike 2008). The objectives of this survey were to assess the abundance, size structure, and population demographics of adult muskellunge in Rice Lake, and make comparisons to the 2007-2008 survey.

## **Methods**

The population abundance of adult ( $\geq 30$  in) muskellunge was estimated using mark and recapture methodology. Muskellunge surveys are two-year fyke netting surveys, so 2014 served as the marking year and 2015 was the recapture year. Fyke nets had 4 X 6 ft. frames with 1-in bar mesh and lead lengths of either 75 or 100 ft. long. Nets were set shortly after ice-out, and checked every 24-h for approximately one week each year. Each muskellunge was measured to the nearest 0.1 in total length, and weighed to the nearest 0.1 lb. The sex of captured fish was determined by presence of eggs or milt or by visual inspection of the urogenital pore as described by LeBeau and Pageau (1989). Aging structures (anal fin rays and scales) and weights were taken during both years. All muskellunge  $\geq 30$  in were marked in 2014, by cutting half the left pectoral fin with a scissors. Fish  $< 30$  in were marked by cutting the right pectoral fin. Fish were checked for marks during the recapture event in 2015. To prevent double-counting fish, all fish handled in 2015 were marked by clipping the top corner of the caudal fin. Abundance of

adult muskellunge was estimated using Chapman's modification of the Petersen single-census method (Ricker 1975):

$$N = \frac{(M + 1)(C + 1)}{(R + 1)} - 1$$

*where N = population estimate; M = the number of fish marked in the first (marking) sample; C = the total number of fish (marked and unmarked) captured in the second (recapture) sample; and R is the number of marked fish captured in the second sample.*

The number of fish collected in 2015 was adjusted for recruitment over a 1-year period. For this, all muskellunge less than 31.5 in were excluded from the adult population estimate because they were assumed to have been less than 30 in during the 2014 marking event. These lengths were determined from recapture data; that is to say, all muskellunge recaptured in 2015 with a left pectoral fin clip were at least 31.5 in and any muskellunge recaptured in 2015 with a right pectoral fin clip was less than 31.5 in.

Several independent abundance estimates were calculated: 1) mature muskellunge of each sex  $\geq 30$  in; and 2) mature muskellunge, sexes combined and unknowns, 30.0-33.9 in, 34.0-37.9 in, 38.0 in and greater, and 40.0 in and greater.

Proportional size distribution (PSD) indices were used to describe population size structure (Guy et al. 2007). PSD values represent the percent of fish stock length or larger that are also larger than a specified length. Stock length was set at 30 in per WDNR protocols. Relative weight (*Wr*) was used to describe condition of muskellunge. Relative weight is the ratio of a fish's weight at capture to the weight of a "standard" fish of the same length determined by the standard weight equation for muskellunge developed by Neumann and Willis (1994). The mean relative weight was determined.

#### Population Demographics:

Muskellunge anal fin rays were cut with a Dremel saw and aged by two interpreters under a dissecting microscope with side illumination from a fiber optic light.

Mean length-at-age comparisons were made with the Barron and Polk County averages, and the regional averages (18 counties in the WDNR Northern Region) obtained from the WDNR Fisheries and Habitat database.

The von Bertalanffy (1938) growth model was determined using mean length at age data to assess growth using the following equation:

$$L_t = L_{inf} (1 - e^{-k(t-t_0)})$$

Where  $L_t$  is length at time  $t$ ,  $L_{inf}$  is the maximum theoretical length (length infinity),  $e$  is the exponent for natural logarithms,  $k$  is the growth coefficient,  $t$  is age in years, and  $t_0$  is the age when  $L_t$  is zero.

Growth equations were calculated separately for each sex due to sex-specific growth differences.

The instantaneous mortality ( $Z$ ) and annual mortality ( $A = 1 - e^{-Z}$ ) rates were determined using a catch curve regression fitted to those ages fully recruited to the gear (Miranda and Bettoli 2007).

## Results

There were up to 16 fyke nets set for nine nights in 2014, which totaled 132 net nights of effort (Figure 1; Table 2). Similarly, there were up to 16 fyke nets set for eight nights in 2015, which totaled 115 net nights. The catch per effort for both years was 0.6 muskellunge per net night. There were 68 adult ( $\geq 30$  in) muskellunge (41 males and 27 females) marked in 2014 and 62 adult muskellunge (27 males and 35 females) collected in 2015. Of the muskellunge captured in 2015, there were 15 (7 males and 8 females) recaptures from 2014. The adult population (sexes combined  $\geq 30$  in) was estimated to be 271 fish (95% CI: 160-382), or 0.29 adult fish/acre (Figure 3). The population in this survey increased since the most recent survey in 2007, when abundance was estimated to be 147 fish (95% CI: 98-196) or 0.16 adult fish/acre.

Population estimates by sex for 2014 were 146 males (CV=0.28) and 111 females (CV=0.27; Table 3). The abundance estimates by length group for 2014 were: 59 from 30.0-33.9 in; 98 from 34.0-37.9 in; 90  $\geq 38$  in; and 69  $\geq 40$  in. Abundance of muskellunge  $\geq 38$  in and  $\geq 40$  in length groups were similar to those in the 2007 survey. However, the abundance of the smaller length groups (i.e., 30.0-33.9 and 34.0-37.9 in) have increased when compared to the 2007 survey.

Muskellunge ranged in length from 12.6 to 48.5 in, and the mean length of muskellunge (sexes combined) was 37.2 in (SE=0.44); the mean length by sex was 34.7 in (SE=0.38) for males, and 39.9 in (SE=0.69) for females (Table 4). The mean lengths

for each sex and the mean length for both sexes combined were all slightly less than the 2007 survey.

Muskellunge PSD34 was 74, PSD38 was 41, and PSD42 was 23 and PSD45 was 12 (Table 5). All PSD indices decreased from the 2007-2008 survey. The greatest declines in size structure from the 2007-2008 survey were in the PSD38 and PSD42 groups which had reductions of 43% and 38%, respectively.

Adult muskellunge collected in this survey were in fair condition. The mean *Wr* was 95, which was a slight decrease from the 2007 survey (Table 6). Mean *Wr* was 97 for fish from 30.0-33.9, 93 for fish from 34.0-37.9, and 96 for fish  $\geq 38.0$ . The *Wr* of all size ranges declined from the 2007 survey.

Rice Lake muskellunge had good growth rates. Mean length at age of Rice Lake muskellunge averaged 1.2 in greater than the Barron and Polk County average and 2.8 in greater than the Northern Region average for ages 3 to 14 (Table 7). No age and growth comparisons could be made with previous surveys because this was the first Rice Lake muskellunge survey with an extensive aging dataset. Mean length at age of female muskellunge were greater than male muskellunge for age 4 and older (Figure 4). The predicted length infinity ( $L_{inf}$ ) from the von Bertalanffy growth model was 47.7 in for female muskellunge, and 40.6 in for male muskellunge.

Muskellunge were fairly long-lived. Ages of muskellunge ranged from 1 to 17. The catch curve regression model (fitted to age 5 to age 17) estimated annual mortality to be 21.7% ( $Z = -0.244$ ,  $R^2 = 0.86$ ; Figure 5).

### **Summary and Discussion**

The density of the adult muskellunge population in Rice Lake was estimated to be 0.29 fish/acre, which was a substantial (81.3%) increase from the 2007 survey when it was found to be 0.16 fish/acre. This increase in the muskellunge population appears to be driven by the increase in smaller size classes. The 30.0-33.9 in size class had an additional 49 fish and the 34.0-37.9 in size classes had 68 additional fish than they did in 2007. However, the large size classes (i.e.,  $\geq 38$  in and  $\geq 40$  in) were similar to those from 2007. Although the increase in the smaller size classes is a good finding, it is likely

unrelated to the increased stocking rate (1.5 large fingerlings/acre) that was reinitiated in 2011, as most of those stocked fish would have been less than 30.0 in during this survey.

The reduction in the PSD38 and PSD42 size structure indices are likely due to the increase in the number of smaller-sized muskellunge observed in this survey, since the abundance estimates for the larger length groups (i.e.,  $\geq 38$  in and  $\geq 40$  in) were essentially unchanged from the 2007 survey. The Rice Lake muskellunge population still has high size structure with a considerable number of muskellunge exceeding 40 in, but unlike the 2007 survey, the smaller size classes were also well-represented.

Muskellunge collected in this survey were considered to be in fair condition based on the *Wr* values, which seemed uncharacteristic for the Rice Lake muskellunge population. The reduction in *Wr* compared to 2007 could be at least partly due to the handling of post-spawn muskellunge in this survey. The Rice Lake muskellunge population is currently at a moderate density and the lake has a robust forage base so the lower *Wr* was not anticipated. However, the below average *Wr* should not be dismissed. Special attention should be paid to the condition and relative weight of the muskellunge population in future population assessments, especially if the density of adult muskellunge continues to increase.

The muskellunge fishery should be managed at a moderate density with high size structure. The target population level of muskellunge in Rice Lake should be maintained between 0.3 to 0.4 adult fish/acre. An adult density within this range should provide a population with high size structure and a respectable density that would offer good angling action. The muskellunge stocking rate should be maintained at 1.5 large fingerlings/acre on an alternate year basis, which should continue to provide increased recruitment and bring the population within the target population density range. This stocking rate is greater than similar waterbodies that are managed for high size structure muskellunge populations; however, it should help compensate for any muskellunge that spill over the dam and emigrate out of Rice Lake. Additionally, this stocking rate is not anticipated to affect the fish community. Being an impoundment on the Red Cedar River, Rice Lake is a productive system with a diverse forage base for the muskellunge population. The sucker and redhorse populations are considered abundant in Rice Lake, and should serve as the primary source of forage for the muskellunge population.

There have been three muskellunge stocking events (i.e., 2009, 2013, and 2015) where PIT-tagged large fingerling muskellunge were stocked into Rice Lake. Several PIT-tagged fish were captured in this survey and these fish provided known-age fish that will shed insight on individual growth histories, and improve our growth, mortality, and longevity estimates. However, due to the expense of PIT tagging large numbers of hatchery muskellunge prior to stocking, it is recommended that we focus on PIT tagging all muskellunge handled in future Rice Lake muskellunge surveys. The anal fin ray should be taken from all PIT-tagged muskellunge, which would provide an accurate age, especially for younger (<10 years) muskellunge. By PIT tagging all muskellunge handled, we will be able to obtain insight on the age, growth, mortality, and general movement patterns of muskellunge at a significantly lower cost relative to PIT tagging muskellunge prior to stocking. Understanding population parameters (i.e., growth, mortality) of Rice Lake muskellunge and comparing them to similar water bodies is critical for proper management of Rice Lake muskellunge in the future. Having reliable age estimates or known-age fish is imperative for assessing these parameters.

Rice Lake continues to have a desirable muskellunge fishery. The Rice Lake muskellunge fishery should be in great shape in the coming years with the increased number of smaller size classes that are recruiting into the fishery. Rice Lake is capable of producing large muskellunge, as documented in this survey and the 2007-2008 survey. Rice Lake muskellunge had above average growth rates and relatively low mortality rates, both of which are good attributes for a trophy fishery. Since this is the first Rice Lake muskellunge survey in which an aging dataset was obtained, it was not possible to make comparisons with the previous survey; however, the ages documented in this survey as well as future PIT tag recaptures should provide a Rice Lake aging dataset that will be useful for future comparisons and management decisions.

### **Management Recommendations**

1. The adult muskellunge population ( $\geq 30$  in) should be maintained between 0.3-0.4 adult fish/acre. PSD42 should be at or above 17, the target level for an A1 muskellunge water.

2. To maintain stable recruitment, Rice Lake muskellunge stocking should continue at the current stocking rate of 1.5 large fingerlings/acre in alternate years. This rate appears to be effective in maintaining a good muskellunge fishery in terms of numbers without compromising the condition of the fish, and it compensates for fish that spill over the dam.
3. Implant passive integrated transponder (PIT) tags into all muskellunge (>20 in) handled in surveys. An anal fin ray should be taken from all tagged fish for aging purposes. Having age information would provide individual growth information and give insight on growth, mortality, longevity, and general movement patterns.
4. Continue with regular monitoring of the Rice Lake muskellunge population. Rice Lake is on a six year sampling rotation and will be surveyed again in 2020.
5. The effectiveness of the 50-in MLL should be assessed in future surveys by documenting any changes in the population size, growth rates, condition, and size structure.

### **Acknowledgements**

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Table 1. Stocking history of large fingerling muskellunge stocked into Rice Lake, Barron County, WI, 1987–2014.

Stocking Year	Age Class	Number Stocked
1987	Fingerling	1,400
1988	Fingerling	1,400
1989	Fingerling	1,400
1990	Fingerling	1,400
1991	Fingerling	1,400
1993	Fingerling	1,900
1995	Fingerling	1,400
1999	Large Fingerling	1,400
2001	Large Fingerling	939
2003	Large Fingerling	939
2005	Large Fingerling	956
2007	Large Fingerling	937
2009	Large Fingerling	939
2011	Large Fingerling	1,409
2013	Large Fingerling	1,408

Table 2. Sampling effort for the 2014-2015 Rice Lake muskellunge survey.

Date	Gear	Survey type	Effort
May 05-14, 2014	Fyke net	Muskellunge marking	132 net nights
Apr 11-19, 2015	Fyke net	Muskellunge recapture	116 net nights

Table 3. Abundance estimates of adult muskellunge by sex and length-group for Rice Lake, Barron County, WI 2007-2014. Coefficient of variation (CV = SD/mean) is in parenthesis.

Year	Sex		Length-group (in)			
	Male	Female	30-33.9	34-37.9	>38.0	>40.0
2007	56 (0.22)	87 (0.23)	10 (0.35)	30 (0.45)	94 (0.18)	64 (0.17)
2014	146 (0.28)	111 (.27)	59 (0.33)	98 (0.35)	90 (0.28)	69 (0.32)

Table 4. Mean (SE) total lengths (inches) of adult muskellunge sampled with fyke nets in Rice Lake, Barron County, WI 2007-2014.

Year	Male	Female	Combined
2007-2008	34.9 (0.70)	42.0 (0.60)	38.0 (0.63)
2014-2015	34.7 (0.38)	39.9 (.69)	37.2 (0.44)

Table 5. Proportional size distribution (PSD) indices for Rice Lake muskellunge, Barron County, WI 2007-2014.

Year	PSD34	PSD38	PSD42	PSD45	PSD50
2007-2008	89	72	36	16	0
2014-2015	74	41	23	12	0

Table 6. Mean relative weight by select length groups and total mean relative weight for adult muskellunge in Rice Lake, Barron County, WI 2007-2014. Whole numbers centered below means are sample size.

Year	30-33.9	34-37.9	$\geq 38.0$	Total
2007	100 (2)	118 (5)	100 (28)	102 (35)
2014-2015	97 (36)	93 (43)	96 (52)	95 (131)

Table 7. Mean length (in) at age for muskellunge (sexes pooled) in Rice Lake, Barron County, WI 2014-2015, the Barron and Polk County average, and the northern Wisconsin (NOR) average.

Age	2014	Barron & Polk	NOR
1	13.0	13.0	11.8
2	—	18.9	15.9
3	26.7	24.7	20.5
4	31.3	29.5	25.6
5	33.3	32.4	28.8
6	34.9	35.1	31.6
7	37.9	36.4	33.8
8	38.1	38.1	36.4
9	39.2	39.6	38.2
10	42.8	41.0	39.4
11	41.3	40.5	41.1
12	46.6	41.9	42.3
13	44.8	44.8	43.1
14	46.2	44.8	45.1
15	—	44.6	43.5
16	48.5	—	—
17	45.0	—	—

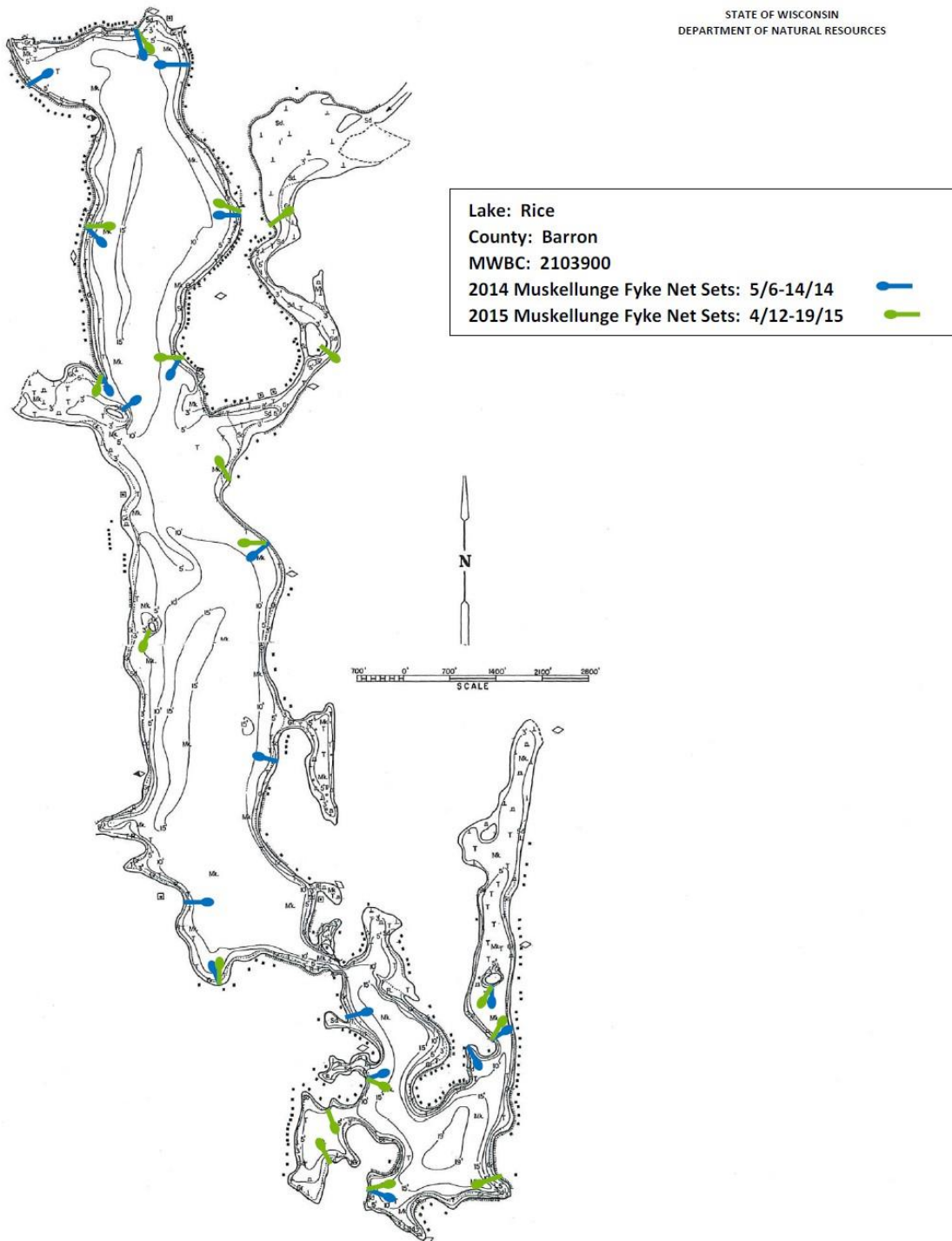


Figure 1. Map of the 2014-2015 muskellunge fyke netting locations for Rice Lake, Barron County, WI.

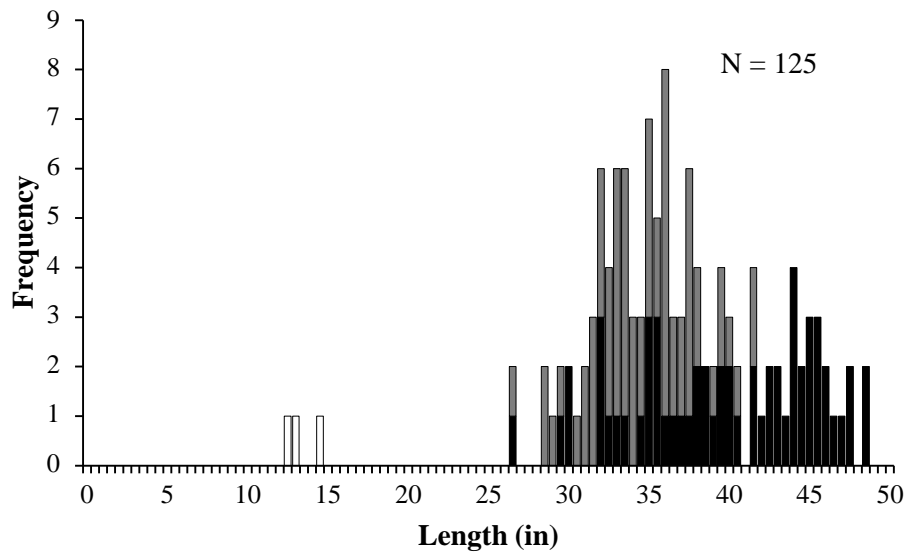


Figure 2. Length frequency histogram for muskellunge captured with fyke nets in Rice Lake, Barron County, WI 2014-2015. White bars represent muskellunge of unknown sex, gray bars represent male muskellunge, and black bars represent female muskellunge. Recaptures were excluded.

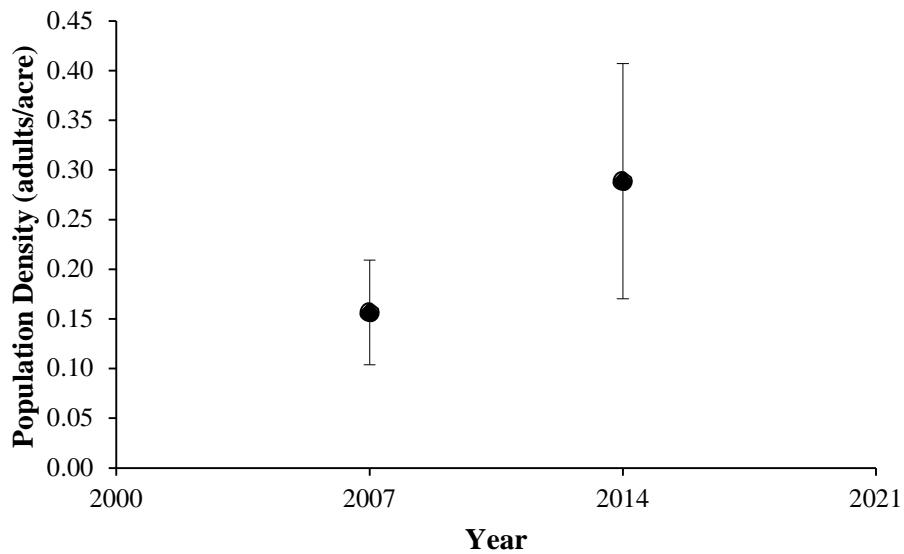


Figure 3. Population density estimates of adult ( $\geq 30$  in) muskellunge (with 95% confidence intervals) in Rice Lake, Barron County, WI 2007-2014.

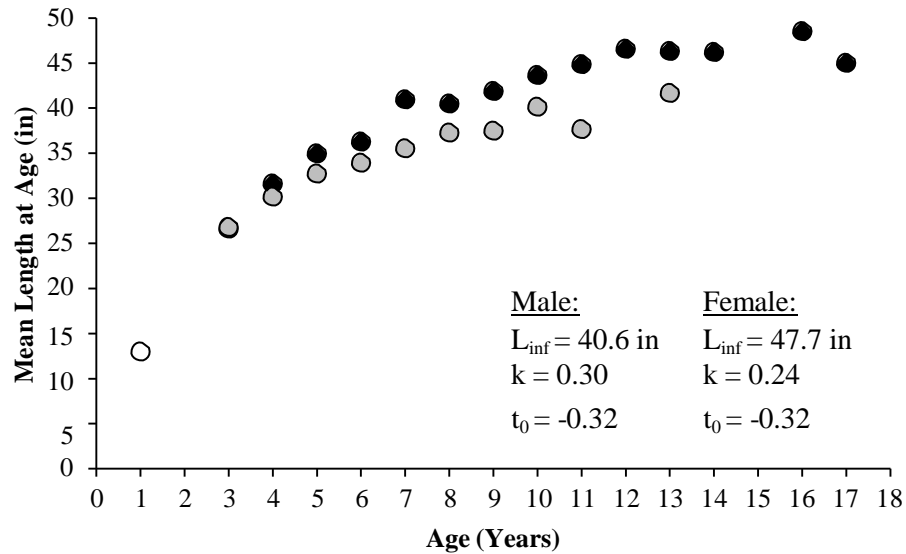


Figure 4. Mean lengths-at-age for female (solid black circles), male (shaded gray circles), and unknown sex (open circles) muskellunge collected from Rice Lake, Barron County, WI 2014-2015. Mean length of age-1 unknown sex muskellunge were included for the growth equations.  $L_{\text{inf}}$  = theoretical maximum length,  $k$  = growth coefficient, and  $t_0$  = time at which length is zero.

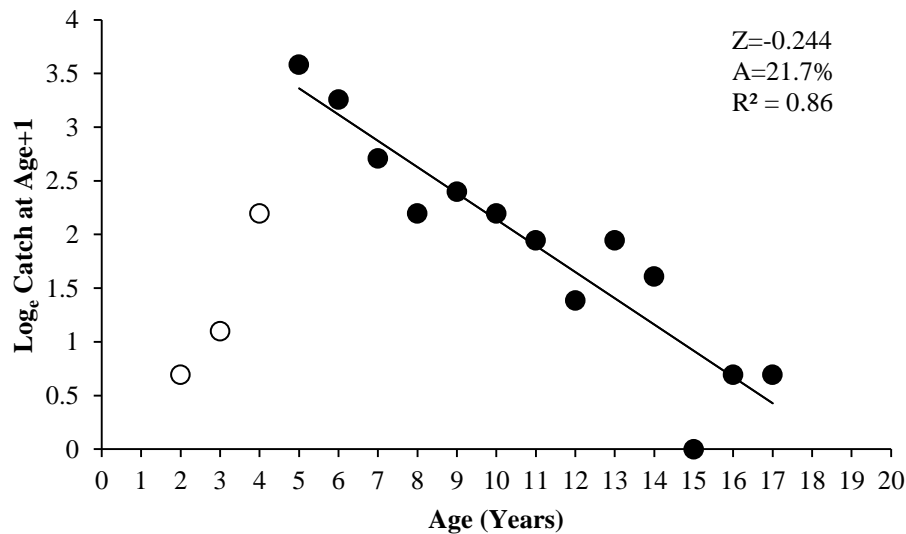


Figure 5. Number at age for muskellunge collected from Rice Lake, Barron County, WI 2014-2015. A catch-curve regression estimated instantaneous annual mortality ( $Z$ ) and total annual mortality ( $A$ ). Ages 2 to 4 were omitted from the regression.